Needs Analysis Report

Addressing Irregular Surface Finish in 3D Printing Operations

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Background Information and Needs Overview

Company XYZ is an additive manufacturing company, specializing in producing complex parts for the automotive industry. An increasing trend of failed prints in the last quarter, due to irregular surface finish was identified by the Quality Control (QC) department. The discrepancy in surface finish quality was assessed through a combination of visual inspection and quality rating data.

Addressing this issue was crucial for the business to improve operational efficiency and customer satisfaction. The request to conduct a needs analysis to address the irregular surface finish issue came directly from the executive committee. By conducting a comprehensive needs analysis, the company aims to gain a deeper understanding of the root cause behind the surface finish errors. This analysis will enable the company to develop targeted instructional interventions that address the potential knowledge gaps, skills deficiencies, or process inconsistencies contributing to the problem. The ultimate goal is to optimize the 3D printing process, reduce failed prints, and deliver high-quality prints consistently.

Probable Causes

Current State	Increased trend of failed prints due to irregular surface finish in 3D prints.
Desired State	Minimized failed prints due to irregular surface finish in 3D prints.

The performance gap between the current state and the desired state was attributed to several probable causes, which were identified by both quantitative *(See appendix A)* and qualitative *(See appendix B)* data collection methods. Based on the data collected, the probable causes for the performance gap can be categorized as a combination of lack of knowledge/skills, lack of resources, lack of motivation, and environmental conditions *(See appendix C)*.

The instructional intervention will primarily target the performance gap resulting from a lack of knowledge. Additionally, the instruction will also address the performance gap associated with lack of motivation by emphasizing the importance of intrinsic motivation, adherence to quality standards, and creating an optimal printing environment. However, as the lack of resources, such as budget constraints, along with environmental conditions cannot be directly addressed through instruction, it is recommended that concurrent efforts be made to address these issues through effective resource allocation, budget optimization, and facility improvements.

The Purpose Statement

The purpose of this training program is to equip learners with the necessary knowledge and skills to improve the surface finish quality of 3D prints, reduce failed prints, and deliver high-quality prints consistently.

Instructional Goals

1. Operators will be able to analyse and apply advanced slicer settings to achieve desired print quality outcomes.
2. Operators will be able to apply best practices for filament loading, nozzle calibration, and bed leveling to ensure consistent and accurate 3D prints.
3. Managers and supervisors will be able to demonstrate effective oversight and support in ensuring the implementation of best practices, providing guidance, and assuring optimal printing conditions.
4. Operators will be able to actively engage in troubleshooting and resolving issues during the printing process, demonstrating increased initiative and problem-solving skills.

Learner and Context Analysis

The target learners for this instructional intervention are 16 operators, 2 operation managers, and 4 shift supervisors of the 3D printing divisional team. The data collected from the learner survey *(See appendix D)* gave the following insights about the learner characteristics.

The operators have varying levels of experience in 3D printing, with some being relatively new to the field, while others have several years of experience. They have received basic training on operating the printers but may lack advanced knowledge of slicer settings, design considerations, and troubleshooting techniques. They also require training on filament loading, nozzle calibration, and bed leveling techniques.

The managers and supervisors are highly experienced technically, however, they have minimal training on coaching and mentorship for the team. Tailored training modules for this group that emphasizes the importance of intrinsic motivation, adherence to quality standards, and continuous improvement initiatives will be beneficial for this group.

In terms of instructional delivery preferences, the learners in this setting prefer a blended learning approach that combines face-to-face training sessions conducted at the company's premises and supported by online resources.

Methodology

To validate the potential performance gap, a comprehensive methodology was employed, combining multiple data sources and analysis techniques. The methodology involved the review of quality reports from the last quarter, a survey, as well as in-depth interviews with key stakeholders *(See appendix A for quality check data, appendix B for interview reports, appendix D for survey questionnaire).* This mixed-methods approach ensured a holistic understanding of the issues and allowed for triangulation of findings.

The quality reports from the last quarter provided quantitative data on the frequency and extent of failed prints due to irregular surface finish. This data helped establish the existence and magnitude of the performance gap. The survey administered to the operators, managers, and supervisors aimed to gather their perspectives, experiences, and perceptions related to the causes of failed prints.

Additionally, in-depth interviews were conducted with operators, managers, and supervisors to gain further insights into their experiences and understand their challenges in addressing the irregular surface finish issue. The interviews allowed for open-ended discussions, enabling the exploration of underlying factors such as environmental conditions, resource availability, and training needs.

Rationale: The validation of the performance gap through the analysis of quality reports, surveys, and interviews ensures a comprehensive and robust understanding of the issue. By triangulating data from multiple sources, the findings can be verified and cross-validated. The combination of quantitative data from Quality Control (QC) sheets and qualitative insights from surveys and interviews provides a holistic view of the problem, enabling us to identify the underlying causes and inform the design of an effective instructional intervention. This methodology allows for a data-driven and evidence-based approach to address the performance gap and improve the surface finish of 3D prints in the workplace.

Findings and Recommendations

Based on the validated performance gap and the identified causes, the following potential interventions are proposed to address the irregular surface finish issue:

Instructional Interventions:

1. Develop a comprehensive training program for operators, focusing on advanced slicer settings, design considerations, and troubleshooting techniques. This program will use a blended approach to provide

in-depth knowledge and hands-on practice to improve their understanding and proficiency in using the slicer software, identifying and resolving issues, and optimizing print settings.

2. Provide hands-on training sessions for operators on filament loading, nozzle calibration, and bed leveling techniques. This training will ensure that operators have the necessary practical skills to handle these critical tasks effectively, leading to improved print quality and reduced failures.
3. Design and deliver targeted modules on coaching and mentorship for managers and supervisors, enabling them to guide and support less experienced operators. This will facilitate knowledge transfer, skill development, and continuous improvement.

Non-instructional Interventions:

1. Improve the availability and accessibility of resources such as high-quality filaments, calibration tools, and maintenance equipment. This will ensure that operators have the necessary resources to achieve optimal surface finish.
2. Enhance the printing environment by addressing factors like temperature, humidity, and lighting conditions. Creating an optimal environment will contribute to better print quality and surface finish.

A combination of instructional and non-instructional interventions is recommended to effectively address the performance gap in surface finish. This holistic approach focuses on enhancing knowledge and skills while optimizing resources, environment, and processes to achieve the desired improvement.

Appendix A

Table 1: Sample Quality Control (QC) Data for Quantitative Analysis

Print ID	Date	Operator	Dimensional accuracy rating (1-5)	Surface Finish Rating (1-5)	Porosity Rating (1-5)	Pass/Fail
P041237	2022-12-23	O09	5	2	5	Fail
P013273	2023-01-12	O03	4	3	5	Fail
P076346	2023-02-23	O05	5	2	5	Pass
P056344	2023-03-30	O12	5	5	5	Fail
…	…	…	…	…	…	…
P052464	2023-06-05	O04	4	2	5	Fail

Appendix B

Table 2: Sample Interview Questions and Summary of Answers for Qualitative Analysis

Interviewee group	Interview Questions	Summary of Answers
Operators	• What is your experience level in operating 3D printers? • Are you familiar with the specific 3D printing technologies used in the company? • Have you received any formal training on operating the 3D printers? • What is your understanding of slicer settings and their impact on print quality? • Have you received any training on advanced slicer settings? • How do you ensure that the print settings are appropriate for each job? • What are the accuracy and precision capabilities of the printers? • How often are the printers calibrated and maintained? • How confident do you feel in adjusting slicer settings to achieve desired print outcomes?	Operators mentioned that they have a basic understanding of slicer settings but lack expertise in advanced settings. 60% operators stated that they have not received specific training on advanced slicer settings. Operators expressed a lack of confidence in adjusting slicer settings for desired print outcomes. Approximately 20% operators mentioned insufficient resources allocated for regular

		maintenance and calibration of 3D printers. About 50% of operators faced challenges related to filament loading, nozzle calibration, or bed leveling.
Managers, supervisors responsible for oversight	• Where does this goal of the desired state come from? • What is done differently in the successful prints compared to the failed prints? • Is there a specific individual or a group of operators that contribute to the failed prints? • How do you evaluate the performance of operators in achieving desired print outcomes? • Why are the operators not performing to the standards? • What changed in the last quarter? • How often do you provide coaching, mentorship, rewards to acknowledge good performance? • How do you communicate high level goals, impacts of the work that happens on the shop floor? • How motivated do the opreators feel in maintaining high quality in the prints? • How do you collaborate with operators and quality control personnel? • How would you describe the quality of the filament used in the printing process? • What are the standard high-quality materials used in the industry? And do you have access to them? • What factors affect the print once it's designed and loaded for the print? • How do you ensure that the quality control personnel are accurate and precise in their jobs? • Have you faced any challenges due to budget constraints?	It was acknowledged that due to budget constraints, there was a challenge in acquiring high-quality materials for printing. Limited budget led to the use of low-quality filament in approximately 20% of the cases, which had an adverse impact on the overall production quality. It was mentioned that the operators took limited initiative in troubleshooting and resolving issues in the process of ongoing prints. It was noted that inadequate lighting conditions is a potential obstacle to accurate visual inspection of prints, which could contribute to inadequate quality check reports.
Design Engineers	• What design-related parameters affect a print's success or failure? • What factors affect the print once it's designed and loaded for the print? • What factors affect the print outside the hands of an engineer or an operator?	The designs are tested in a simulation before the actual print. Only designs that pass the simulation proceed to printing. This validates that

	• How often do you provide guidelines or recommendations to ensure a successful print? • Are there any considerations regarding the selection of filaments for specific print jobs? • How would you describe the quality of the filament used in the printing process? • What are the standard high-quality materials used in the industry? And do you have access to them?	there are no probable causes related to the design process. However, it was pointed out that variations in temperature and humidity affect surface finish quality and prints are susceptible to this. It was also observed that low quality filament materials are used occationally because of budget constraints.

Appendix C

Table 3: Sample Data Analysed for Probable Causes

Actual Performance	Desired Performance	Primary Cause	% of Performance Gap
Operators have limited understanding of advanced slicer settings and their impact on print quality. Lack of hands on training for advanced slicer settings. Inadequate familiarity with best practices for filament loading, nozzle calibration and bed leveling.	Operators have extensive understanding of advanced slicer settings and their impact on print quality. Sufficient hands-on training for advanced slicer settings. Familiarity with best practices for filament loading, nozzle calibration, and bed leveling.	Lack of knowledge and skill	65%
Insufficient budget allocation for necessary equipment, materials, and maintenance, resulting in compromised print quality. Insufficient resources allocated for regular maintenance and calibration of 3D printers.	Sufficient budget allocation for necessary equipment, materials, and maintenance. Sufficient resources allocated for regular maintenance and calibration of 3D printers.	Lack of resources	10%

Limited initiative in troubleshooting and resolving issues in the process of ongoing prints.	Increased initiative in troubleshooting and resolving issues in the process of ongoing prints.	Lack of motivation	15%
Inconsistent temperature and humidity levels in the printing environment affecting print quality. Poor lighting conditions hindering accurate visual inspection of prints.	Consistent temperature and humidity levels in the printing environment affecting print quality. Optimal lighting conditions hindering accurate visual inspection of prints.	Environmental conditions	10%

Appendix D

Survey Questionnaire for learner analysis:

1) How many years of experience do you have in 3D printing?
    a. Less than 1 year
    b. 1-3 years
    c. 3-5 years
    d. More than 5 years

2) Have you received any formal training on the basic operation of 3D printers?
    a. Yes
    b. No

3) Have you received any formal training on the avanced knowledge of slicer settings, design considerations, and troubleshooting techniques?
    a. Yes
    b. No

4) On a scale of 1-5, rate your knowledge level regarding advanced slicer settings
    (1 - Low, 5 - High)

5) How comfortable are you with filament loading, nozzle calibration, and bed leveling techniques?
    a. Not comfortable at all

   b. Somewhat comfortable
   c. Moderately comfortable
   d. Very comfortable
   e. Extremely comfortable

6) How often do you face challenges or issues related to irregular surface finish in 3D prints?
   a. Rarely
   b. Occasionally
   c. Frequently
   d. Almost every time

7) How confident do you feel in troubleshooting and resolving issues during the printing process?
   a. Not confident at all
   b. Somewhat confident
   c. Moderately confident
   d. Very confident
   e. Extremely confident

8) How familiar are you with coaching and mentoring techniques for the team? (if applicable)
   a. Not familiar at all
   b. Somewhat familiar
   c. Moderately familiar
   d. Very familiar
   e. Extremely familiar

9) Have you received any formal training on coaching and mentoring techniques for the team? (if applicable)
   a. Yes
   b. No

10) On a scale of 1-5, rate your level of motivation in ensuring adherence to quality standards.
   (1 - Low, 5 – High)

11) Which instructional delivery method do you prefer?
   a. Face-to-face training sessions
   b. Online training modules
   c. Blended learning approach (combination of face-to-face and online)